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DYNAMIC TRUNK STABILITY DURING SITTING IN YOUNG AND ELDERLY INDIVIDUALS

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Abstract

Objective : It is difficult to precisely define trunk balance in standing position because postural sway is controlled by the lower limbs. Therefore, we safely determined trunk balance in sitting position using a new device.

Materials & Methods : Twenty-eight healthy elderly volunteers and Twenty-eight healthy young volunteers were participated. Postural sway was measured while seated using a new balance device. The device inclines the seat to the right and left 0.6 Hz. A force plate underneath a seat slanted to a maximum of 3° tracks the location of the center of pressure. We evaluated locus length (LNG), locus length/second (LNG/TIME), enveloped area (ENV-AREA), root mean square area (RMS-AREA) and locus length per unit area (LNG/AREA).

Result : Values for LNG, LNG/TIME, ENV-AREA, and RMS-AREA were significantly worse for the elderly, compared with the young group ($p<0.01$). However, LNG/AREA did not significantly differ between the two groups ($p=0.0136$).

Conclusion : LNG/AREA did not significantly differ between young and elderly participants witch suggest that our device could precisely measure trunk balance without any influence of the lower extremities. Trunk balance can be safely examined in elderly people with a new device.

Key words : trunk stability, sitting position, center of pressure (CoP)

Introduction

Imbalance with aging is regarded as an important factor that is associated with falls[1)]. Falls in elderly people are the leading cause of fractures of the lower extremities and a decrease in quality of life. Elderly patients who suffer from hip fracture easily become bedridden or die from systemic complications. More than 70% of hip fractures occur as a result of falls in Japan[2)]. Therefore, body balance needs to be evaluated to identify risk factors of falls for elderly people.

Evaluation of the ability for balance is often determined by using stabilometry, which is the objective study of body sway during quiet standing. Body sway increases by aging in stabilometry[3)]. However, measurement of body sway in the standing position has a risk of falls in elderly people. Body sway measured in the sitting position and standing position increases with aging[4)]. Evaluation of body sway in the sitting position is safe because of the wide base of support. However, there is the problem that a significant difference in measurements in the sitting position is difficult to determine compared with

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the standing position[5].

The sitting position is not associated with the standing position regarding body sway in the front and back (a sagittal plane) direction, but body sway in the sitting position is similar to standing position in the medio-lateral (a coronal plane) direction[6]. There is a decrease in ability for medio-lateral balance in elderly people[7]. Furthermore, a sideways fall onto the hip is known to be a clear risk factor for hip fracture in elderly people[8]. Medio-lateral balance needs to be evaluated to identify risk factors of falls for elderly people.

We manufactured a new device which inclines a seat to the right and left in the coronal plane while tracking the center of pressure (CoP). In this study, we safely measured dynamic trunk balance in seated elderly and young people using a new device.

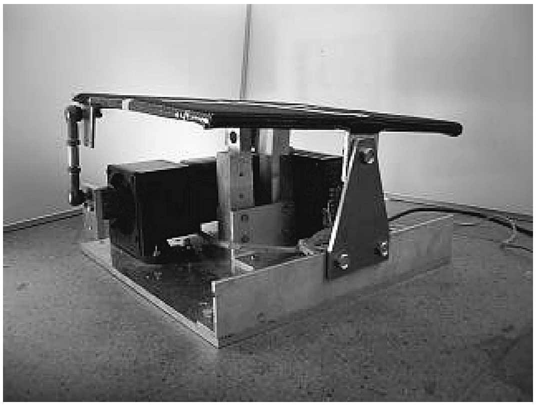

Fig. 1. A novel balance device.

Fig. 2. Participant positioned on the new device during measurements. They didn't touch the floor with their feet.

Methods

Subjects

A total of 28 healthy elderly volunteers (mean age, 76±5 years) and 28 healthy young volunteers (mean age, 28±8 years) participated in this study (Table 1). No participants displayed any neurogenic or vestibular or visual disorder known to impair balance. They did not have a history of falls in the past years. A full explanation was given to the patients before taking part in this study and informed consent was obtained.

Protocol

Postural sway was measured while being seated using a new balance device (Fig. 1) that we recently manufactured in-house. The new device has a speed control motor (BHM62MT-G2) for driving with an AC electro-

Table 1. Participants background data

	Young group	Elderly group
Number.of participants	28	28
Age (year)	28±8 (15-44)	76±5 (70-85)
Gender (M : F)	16 : 12	12 : 16
Height (cm)	165.2±8.8	158.5±9.5
Wight (kg)	62.2±14.7	55.7±9.2

Values represent mean ± Standerd Deviation

Table 2. Definition of parameters

LNG (mm)	Total distance taraveled by the CoP
LNG/TIME (mm/s)	Total distance taraveled by the CoP divided by time indicating sway speed
ENV-AREA (mm^2)	Total area envelope by the track of the CoP indicating the spatial spread of the swaying
RMS-AREA (mm^2)	Root mean square area is the root of the quotient of the sum of the squares of the distances of the samples
LNG/AREA (mm/mm^2)	Locus length per unit area indicating fine control of standing posture by proprioceptive reflexes

LNG : locus length, LNG/TIME : timed track length, ENV-AREA : enveloped area, RMS-AREA : root mean square area, LNG/AREA : locus length per unit area, CoP : center of pressure

magnetic brake (Oriental Motor Co., Ltd. Tokyo, Japan) for surfaces with a slant. We used three triaxial force sensors (USL06-H5, Tec Gihan Co. Kyoto, Japan) for measurement of the reaction force. These sensors are placed in the shape of an isosceles triangle under the bearing surface. A bearing surface slanted to a maximum of 3° tracks the location of the center of pressure (CoP) of a seated person. The device inclines the seat to the right and left six times for 10 seconds each (0.6 Hz). The height of the weight-bearing surface is adjustable so that the participants cannot touch the floor with their feet. This avoids balance being affected by the lower extremities. The participants kept their arms crossed to avoid protective reactions of the upper extremity and their gaze fixed upon a point 2 m ahead. We then measured CoP for 30 seconds (Fig. 2). We measured sitting balance three times each, and we used data from the last measurement to exclude accidental motility because of inexperience.

We evaluated the locus of CoP, locus length (LNG), locus length per second (LNG/TIME), enveloped area (ENV-AREA), root mean square area (RMS-AREA), and locus length per unit area (LNG/AREA) (Table 2). These parameters are used by platform stabilometry[9,10].

Differences in these parameters between young and elderly subjects were compared using the Mann-Whitney test. All of the data were analyzed using SPSS version 19.0 for Windows (SPSS Inc, Chicago, IL, USA). Significance thresholds were set at 0.01.

Results

LNG in the young group was significantly shorter than that in the elderly group (1011.8 mm versus 1,466.0 mm, $p<0.0001$; Fig. 3). LNG/TIME in the young group was significantly faster than that in the elderly group (33.7 mm/s versus 48.9 mm/s, $p<0.0001$; Fig. 3). ENV-AREA and RMS-AREA in the young group were significantly smaller than those in the elderly group (333.0 mm^2 versus 561.4 mm^2, $p<0.0001$; Fig. 3) (234.9 mm^2 versus 426.2 mm^2, $p<0.01$; Fig. 3). There were no significant differences between young group and elderly group in LNG/AREA (3.7 mm/mm^2 versus 2.6 mm/mm^2, $p=0.0136$; Fig. 3). The mean values for LNG, LNG/TIME, REC-AREA, ENV-AREA, and RMS-AREA were significantly worse for the elderly group compared with the young group. However mean values for LNG/AREA were not significantly different between the two groups.

Complications, such as falls from the device, did not occur during the examination.

Discussion

Trunk stability plays an important role in maintaining spinal posture and fall. Lumbar kyphosis affects postural balance and represents a risk factor for falls[11]. Lumbar kyphosis, spinal inclination, mobility of the lumbar spine, and mobility of spinal inclination are significantly associated with falls in elderly individuals[12]. Back extensor strength is significantly associated with lumbar lordosis, indicating the potential importance of strengthening the back extensor for improving or maintaining lumbar lordosis[13]. Trunk stability seems to contribute to the fall risk. There are many clinical assessment tools of balance[14,15]. However, trunk stability has few quantitative evaluation tools[16,17].

Balance control has four underlying factors ; standing balance, ability to withstand perturbations, leaning balance with a stationary base of support and dynamic bal-

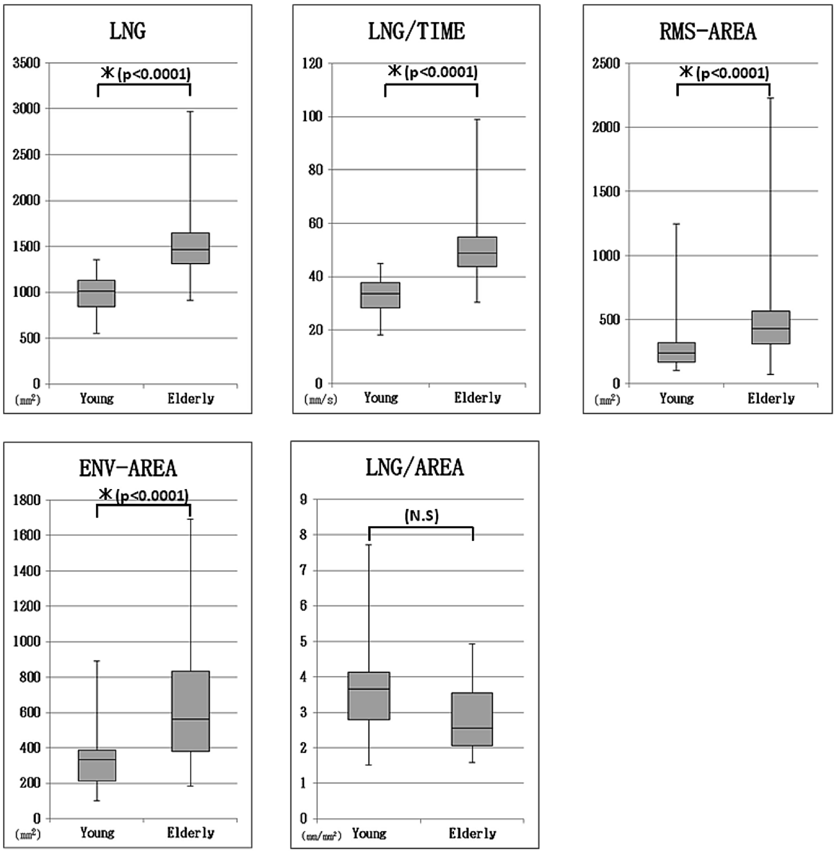

Fig. 3. Comparison of variables between young and elderly. The locus length per unit area (LNG/AREA) was not significantly different between the two groups. N.S : Not significant.

ance with movement of the base of support[18]. Most of falls are due to sudden disturbance such as slip and trip[19]. Therefore, dynamic balance evaluation and ability to response for perturbations are required to identify fall risk.

The new sitting balance device was able to safely and precisely measure dynamic trunk balance in the mediolateral direction without any influence of the lower extremities. Considering the results of current study, locus length per unit area reflects minute postural adjustments controlled by the spinal proprioceptive reflex of the lower extremities[20]. Our sitting balance device could precisely measure trunk balance without any influence from the lower extremities, which may explains why LNG/AREA did not significantly differ between young and elderly participants. These findings indicate that dynamic trunk balance can be safely examined in elderly people with a new device.

The association between dynamic trunk balance and fall risk assessment should be evaluated with tests, such as the Functional Reach Test[21] and Timed Up and Go Test[22], widely used in the clinical setting. In addition, the relationship between trunk balance function and walking ability in elderly people should be evaluated.

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